RAW MATERIALS

UDC 666.366

FELDSPAR MATERIAL FROM KARELIA FOR ELECTRICAL ENGINEERING

V. P. Il'ina[1]

Translated from Steklo i Keramika, No. 6, pp. 24 – 25, June, 2004.

The possibility of using quartz-feldspar rocks from Karelia for the production of electrotechnical ceramics is demonstrated. It is established that sintered samples of alkaline sienite have low dielectric losses (0.25) and a dielectric permeability equal to 6.5. The volcanogenic rocks (quartz porphyry with a high content of quartz and microcline) decrease the dielectric permeability of the samples to 5.4 and the dielectric permeability of potassium halleflinta is equal to that of pegmatite, i.e., 7.7.

Feldspar in the production of electrotechnical porcelain is used as a fluxing agent that forms a vitreous phase providing for sintering of the mixture. The vitreous phase influences the mechanical, electrical, and other properties of porcelain to a large extent depending on the mineralogical composition of the feldspar. The most commonly used is feldspar with a high content of microcline and plagioclase. A variety of such feldspar is produced from the pegmatite of the Chupino-Loukhskii group of deposits in Northern Karelia. Currently new type of materials are used for electrotechnical products, in particular feldspar material with a high content of quartz ensuring its cristobalizing, causing the formation of mullite and crystallization of the vitreous phase. In this context, it is important to investigate new kinds of materials that could meet the requirements of the electrotechnical industry [1, 2].

In our research we investigated quartz-feldspar rocks from Karelia, including alkali sienite, applite, and volcanogenic rocks including quartz porphyry and halleflinta and compared them with traditional pegmatite for the purpose of identifying their suitability for producing electrotechnical porcelain.

The electric properties (dielectric permeability ε, loss-angle tangent $\tan\delta$, and electric resistivity ρ) were determined on sintered samples (material in the vitreous state; in the form it exists in porcelain) prepared from finely milled (particle size 0.063 μm) and deferrized powder of quartz-feldspar rocks by melting it in crucibles at a temperature of 1350°C. Samples for measurements were prepared by grinding sintered cakes on an abrasive wheel to a diameter of 20 – 25 mm and height 2 – 3 mm. The measurements of ε, $\log\rho$, and $\tan\delta$ were performed using a capacity bridge E-7-8 at a frequency of 10^3 Hz and temperature of 20°C. The electric properties were calculated using an additional coefficient to take into account the additional capacity on the sample sites not covered by the electrodes according to the following formulas:

$$\varepsilon = K_1 K_2 C; \quad \log\rho = \frac{K}{gl}; \quad \tan\delta = 0.175\,\frac{g}{C},$$

where $K_1 = 1.14$ and $K = 33.55$ are the sensor coefficients; K_2 is the sample thickness coefficient; C is the electric capacity of the sample; g is the electric conductivity; l is the sample thickness.

The results of measuring the electric properties of sintered feldspar rocks are listed in Table 1 and the dependence of the variation of ε, ρ, and $\tan\delta$ on the quantity of microcline and plagioclase in the sample is shown in Figs. 1 and 2.

The electric parameter characterizing the properties of porcelain is its dielectric permeability depending on the ability of cations of the vitreous and crystalline phases to polarize in an electric field. The dielectric permeability of sintered samples of the quartz-feldspar rocks analyzed (1 – 12) is within the range of 3.26 – 7.70, and that of the pegmatite from the Chupino-Loukhskii group of deposits, according to the data in [3, 4], varies from 5.6 to 7.7. The analysis of the dielectric permeability of quartz-feldspar rocks and pegmatite indicates that this parameters in sienite and granite-applite has a lower value than in pegmatite, whereas in the vulcanite (halleflinta) of the Kostomukshinskoe deposit is equal to that of the pegmatite and depends to a great extent

[1] Institute of Geology of the Karelian Research Center of the Russian Academy of Sciences, Petrozavodsk, Russia.

0361-7610/04/0304-0195

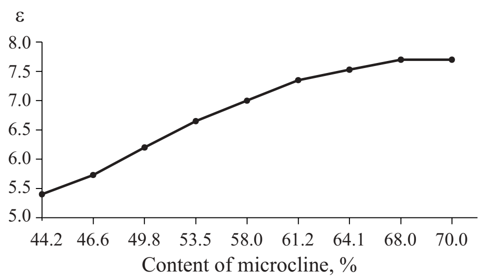

Fig. 1. Dielectric permeability of sintered samples ε versus mass content of microcline in quartz-feldspar rocks.

on the mineralogical composition of the material. Microcline and quartz have the most perceptible effect on dielectric permeability. A high content of quartz (44%), in contrast to other rocks, in the vulcanites from the Roza-Lambi deposit (sample 7) facilitates a decrease in dielectric permeability of the sample to 5.4.

The type of variations in the dielectric permeability of samples depends on the quantity of microcline both in the traditional pegmatite (samples 1 – 5) and in sienites, granites, and volcanites (Fig. 1). The dielectric permeability of sintered plagioclase rock samples (10 – 12) differs from that of the microcline samples in their low values (3.26 – 4.02), which is presumably related to the presence of Ca^{2+} ions in samples 11 – 12 and Ba^{2+} ions in sample 10. It is known that the dielectric permeability of porcelain decreases when K^+ and Na^+ cations are replaced by Ca^{2+}, Mg^{2+}, and Ba^{2+} cations.

It can be seen from Fig. 2 that a high content of microcline and plagioclase in quartz-feldspar rocks results in a low loss-angle tangent in sintered samples [0.045 for potassium halleflinta (sample 8), 0.025 – 0.032 for sienite (sample 10), and 0.027 for pegmatite (sample 6)], and raises their electric resistance (1.23×10^{10}, 2.00×10^{10}, and 2.10×10^{10} Ω · cm, respectively). According to GOST 20419–89, the dielectric

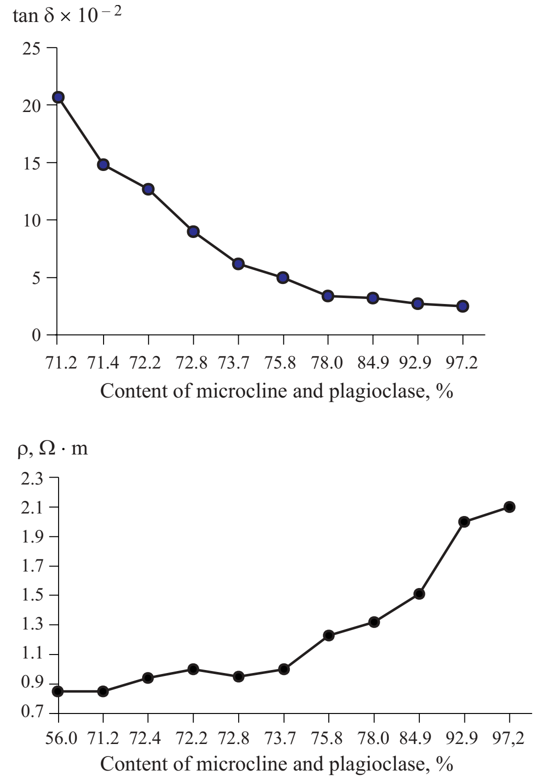

Fig. 2. Dependence of loss-angle tangent and resistivity of sintered samples on the composition of quartz-feldspar rocks.

permeability of electroporcelain based on alkali aluminosilicate should not exceed 7, and the loss-angle tangent should not exceed 0.025. Low dielectric losses (0.025) and dielectric permeability equal to 6.5 are typical of sienite from Elisenvara (sample 10).

As a consequence of studying the electric properties of sintered quartz-feldspar rocks it was found that the high content of microcline and quartz in the Roza-Lambi vulcanite

TABLE 1

Sample	Technological type	Mass content %				Electric properties		
		quartz	microcline	plagioclase	orthoclase	ε	ρ, 10^{-10} Ω · cm	tan δ
	Pegmatite:							
1	Chupino-Loukhskii	2.5	70.0	27.5	–	7.70	–	–
2		28.6	64.1	7.3	–	7.53	0.94	0.148
3		24.2	61.3	14.5	–	7.35	1.00	0.062
4	Priladozhskii	27.2	49.8	23.0	–	6.20	0.95	0.900
5		27.8	46.6	25.6	–	5.73	1.00	0.127
6	Ulyalegskii field	7.1	58.0	34.9	–	7.00	2.10	0.027
	Vulcanite:							
7	Belomorskii	44.0	44.2	11.8	–	5.40	0.85	0.160
8	Kalevalskii	24.2	68.0	7.8	–	7.70	1.23	0.050
	Sienite:							
9	Loukhskii	23.1	53.5	31.4		6.65	1.51	0.032
10	Priladozhskii	12.8	43.0	54.2	–	3.26	2.00	0.025
11	Loukhskii granite-applite	29.1	–	40.4	30.8	3.87	0.85	0.207
12		22.0	–	66.9	11.1	4.02	1.32	0.034

(sample 7) facilitates a decrease in dielectric permeability to 5.4 and resistivity ($0.85 \times 10^{10}\ \Omega \cdot cm$) compared to pegmatite. The alkali sienite from Elisenvara (sample 10) with a high total content of microcline and plagioclase (97%) and with Ba^{2+} ions typically have a low dielectric loss (0.025) and a high resistivity ($2.0 \times 10^{10}\ \Omega \cdot cm$) compared to other rocks.

The Elisenvara sienites are of the highest interest for the production of electrotechnical porcelain.

REFERENCES

1. G. N. Maslennikova, F. Ya. Kharitonov, N. S. Kostyukov, and K. S. Pirogov, *Technology of Electroceramics* [in Russian], Énergiya, Moscow (1974).
2. V. P. Il'ina, "Technological evaluation of feldspar rocks from the Loukhskii district," in: *Geological-Technological Evaluation of Industrial Minerals and Rocks in the Republic of Karelia and Certain Regions of the European Continent* [in Russian], Petrozavodsk (1997), pp. 57 – 59.
3. M. I. Golod, L. L. Grodnetskii, and B. N. Klabukov, "On dielectric permeability of plagioclase from a pegmatite vein of the Kola Peninsula," in: *Minerals as Indicators of the Specifics of Their Incorporating Medium* [in Russian], Nauka, Leningrad (1975), pp. 47 – 49.
4. N. I. Kholodok, M. I. Golod, A. I. Popova, and B. N. Klabukov, "Dielectric permeability of potassium feldspars from pegmatite veins," in: *Pegmatites of Karelia and Kola Peninsula* [in Russian], Petrozavodsk (1977), pp. 160 – 164.